SMAP (Soil Moisture Active & Passive) Mission Concept/Cost Assessment Study

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(Representing the JPL SMAP Assessment Study Team)

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SMAP Mission Study Overview

- After the release of the NRC Earth Science Decadal Survey Report, NASA requested JPL to conduct an assessment of the SMAP mission design maturity, implementation readiness, and cost realism
- JPL Assessment Team & Resources:
  - Study Lead: Eastwood Im (CloudSat Instrument Manager)
  - Selected members of the JPL Mission Systems Concept Section and Radar Science and Engineering Section
  - JPL Advanced Project Design Center (TeamX) tools and resources
- Approach:
  - Reviewed technical and implementation content and applicability of the ESSP Hydros mission (which addresses the core science objectives of SMAP)
  - Conducted TeamX mission design studies
  - Cross-compared and reconciled TeamX results, Hydros baseline, several cost models, and relevant components of the Aquarius mission payload
  - Documented findings
  - Report sent to NASA on 6/15/07

SMAP Mission Study: Key Findings

- The core science objectives and requirements of the SMAP mission (those on soil moisture and freeze/thaw) are similar to those addressed by the ESSP Hydros mission. Therefore, SMAP can take advantage of the work performed in the past several years for Hydros
- SMAP instruments (L-band radar and radiometer electronics) has significant design heritage from Aquarius. SMAP instrument cal/val can also take advantage of the Aquarius experience
- SMAP mission is consistent with the cost estimate given in the NRC report
  - SMAP mission cost estimate does not assume the Hydros-type partnership contributions
- SMAP mission design/technology are mature. It is ready to begin formulation
- Although the design maturity comes from the stability of the core science objectives, mission operations can be adjusted to accommodate opportunistic science.

SMAP Mission Summary

Science Measurements

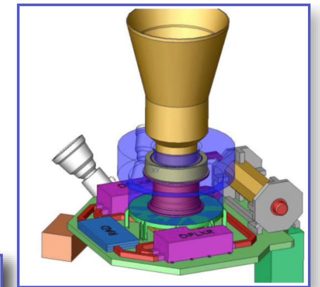
- *Measure soil moisture and freeze-thaw state*
- *2-3 days global revisit*

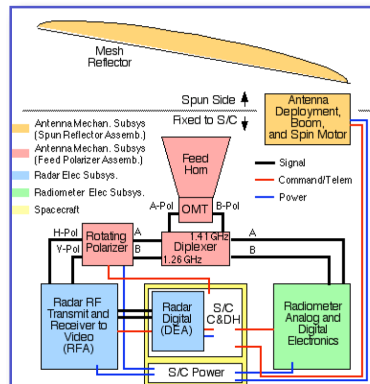
Mission Objectives

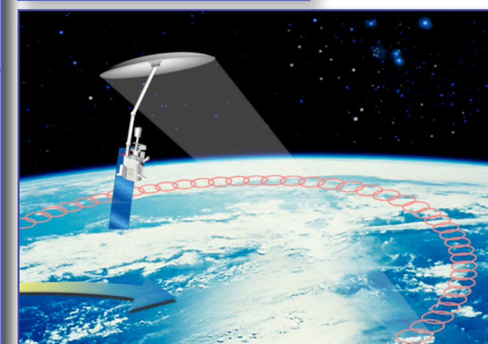
- *First dedicated soil-moisture and freeze/thaw mission using L-band active/passive combination*
- *Provide soil-moisture observations to the NPOESS community*

Mission Overview

- *Launch Date: January 2013*
- *Launch Vehicle: Taurus-class*
- ***Mission life of 3 years****
- *Sun-synchronous dawn/dusk orbit, 670 km altitude*
- ***Estimated cost** is in the $350M to $400M range (in FY07$)***







Instruments

- *L-band radar and radiometer system with offset-fed 6-m deployable mesh reflector rotating about nadir axis*
- *Unfocused synthetic aperture processing provides higher resolution radar measurements*

**** Hydros mission life: 2 years***
***** Decadal Survey rough cost estimate: $300M ± 50% (in FY06$)***

Design Maturity

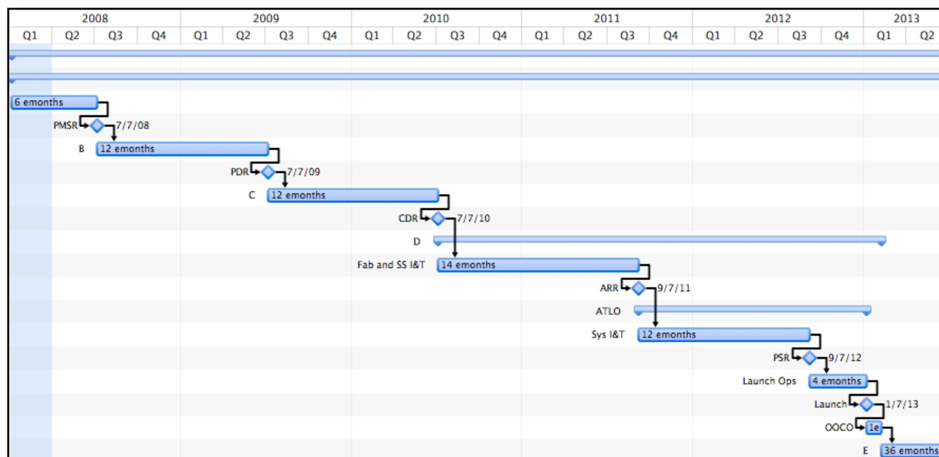
SMAP Observatory Mass

Spacecraft Bus	302 kg
Required Fuel Load	33 kg
Instrument	189 kg
Space Vehicle Total	524 kg
Taurus Capability	775 kg
Mass Margin	251 kg (33%)

Key SMAP Resources

System Power	866 W	(34%)
Attitude Control	0.1	(36%)
Attitude Knowledge	0.03	(36%)
Instrument Momentum	300 Nms	(50%)
High-res Data Storage	100 Gbit	(100%)
Low-res Data Storage	10 Gbit	(6.7X)
On-board Data Rate	20 Mbps	(25%)

- Development - phase A-D: 5 years
  - Phase A start: January 2008
  - PDR: July 2009
  - CDR: July 2010
  - Launch: January 2013
  - Adequate schedule reserve (costed)
- Operations: 3 years



Requirement/design maturity and heritage from Hydros enable an early project start, leading to science data acquisition beginning in early 2013.

Next Steps Toward Baseline Mission as Identified by the Mission Study Team

- **Mission design studies**
  - Verify battery, solar array, radiation effects for a 3-year baseline mission (and 6-year consumables)
    - Hydros operations phase was planned for two-years
- **Spacecraft selection**
  - Single S/C supplier selected as partner on ESSP Hydros
  - Hydros vendor option still viable, but evaluation of other vendors' capabilities is recommended
- **Antenna selection**
  - Two deployable antenna concepts from separate vendors shown feasible for Hydros.
  - For SMAP, this study team recommends:
    - Down-selection to single antenna vendor
    - Perform additional dynamics studies to validate model fidelity
- **Investigate joint partnership opportunities**

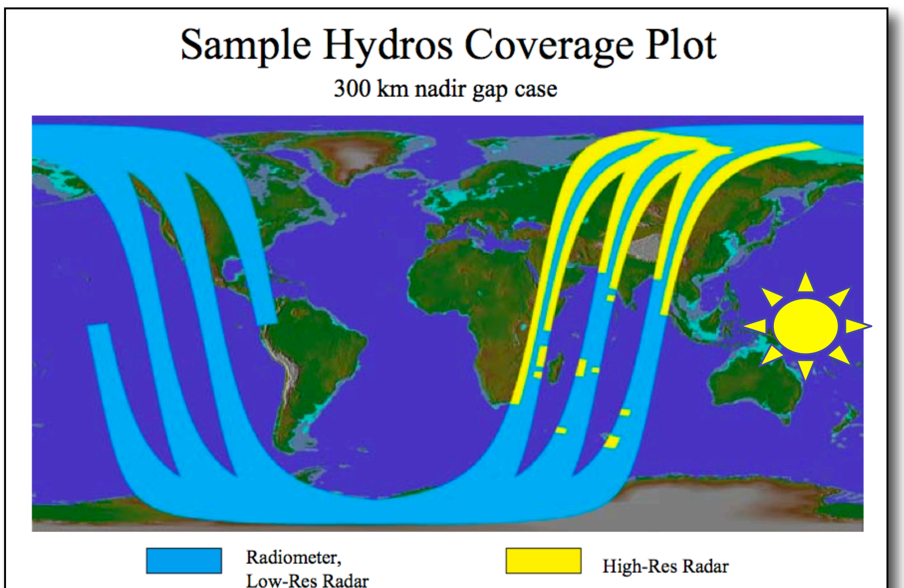
Exploring Enhanced Science and Applications Enabled by SMAP

- SMAP is defined as a Soil Moisture and Freeze/Thaw mission but the NRC also recognized its potential for contributing to other science areas.
- The previous slides discussed a mission that can deliver SMAP core science products for a cost consistent with the decadal survey estimate.
- In the reminder of this presentation, we will present scenarios by which SMAP can be augmented to enable additional/opportunistic science and applications without altering the core science objectives.
  - Enhanced data acquisition scenario
  - Additional data products

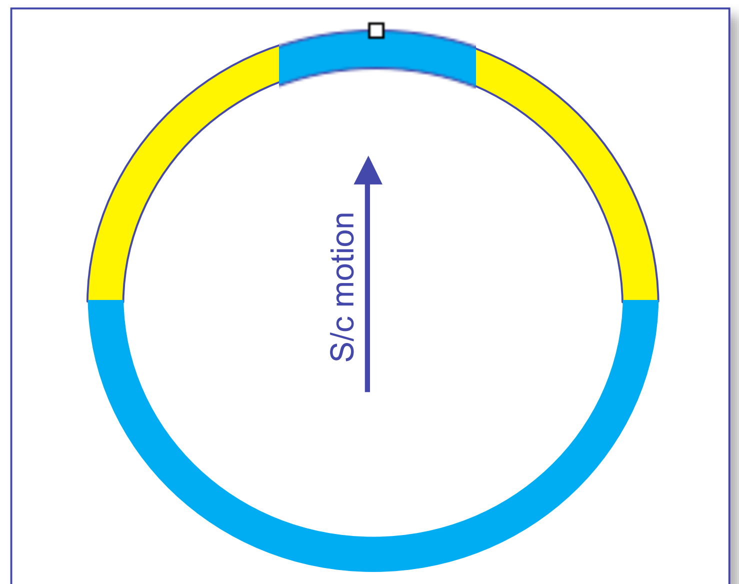
Extracted from NRC ES Decadal Survey Report
Where possible within budget constraints, the augmentation of the specified set of science observations with additional desired observables should be considered; however, NASA and the scientific community must avoid "requirement creep" and the subsequent damaging cost growth.

Baseline Data Acquisition Scenario

- Low-resolution radar and radiometer data acquisition throughout 360˚ scan (~1000 km contiguous swath)
- High-resolution radar data are acquired in left and right portions of forward scan when the following conditions are met:
  - Swath covers land (Antarctica excluded)
  - Local time is close to 6 am (reduced ionospheric interference effects)



3 orbits coverage



Radiometer & Low-resolution radar

High-resolution radar

Examples of Potential SMAP Enhancements/Augmentations

- High-resolution Radar Coverage
  - Increased high-res data coverage may be desirable for enhanced science.

	Baseline(1)	Enhancement	Data volume increase(2)	Science benefit of enhancement
Portion of scan	< half scan	Close to full scan	x 2	Workshop inputs
Portion of orbit	AM	AM and PM	x 2	
Target mask	Land only	Land and Ocean	x 3	

  - Increased data-volume affects on-board data storage, downlink and ground station capabilities.

- Improved data latency/reliability
- Additional standard data products for enhanced science

(1) *The baseline is defined as the scenario that meets the core science requirements (soil moisture and freeze/thaw).*

(2) More details will be discussed at the breakout session.

Near-term Trades and Study Tasks for Enhanced Science / Applications

- **Workshop**
  - Discuss and document benefit vs. added complexity of potential enhancements/augmentations to SMAP core mission
  - Recommend and prioritize enhancements/augmentations

- **Post-Workshop studies**
  - Analyze and document cost impact of accommodating recommended enhancement/augmentation into core mission design

- **Investigate joint partnership opportunities**